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(54) Layered steel cord construction.

(57) A steel cord (14) comprises a core filament (16) with a first diameter d_1, four or five intermediate layer filaments (10) with a second diameter d_2 and ten outer layer filaments (20) with a third diameter d_3. The intermediate layer filaments (10) surround the core filament (16) and the outer layer filaments (20) surround the intermediate layer filaments (10). The first diameter is substantially smaller than the second diameter and is substantially greater than the diameter of the circle (12) inscribed in the compact figuration of the cross-sections of the intermediate layer filaments (10) in case of no core filament. Such a steel cord has a full rubber penetration.

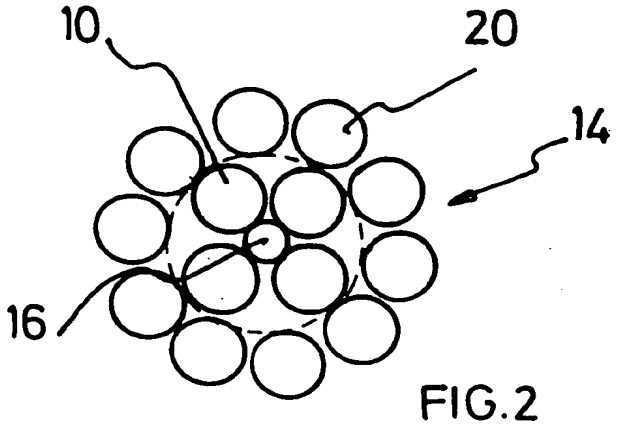

FIG.2

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FIELD OF THE INVENTION

The present invention relates to a steel cord for the reinforcement of rubber articles an to a rubber product, particularly a heavy truck tire the belt of which comprises such a steel cord.

BACKGROUND OF THE INVENTION

Amongst the number of steel cord constructions which are presently used for the reinforcement of rubber products the 3+9+15-steel cord construction still keeps an important place despite a number of disadvantages and the existence of compact cords.
A particular example of a 3+9+15-construction is as follows :

3x0.22 + 9x0.22 + 15x0.22 + 1 S/S/Z/S 6.5/12/18/3.5

Such a construction has following disadvantages.
It makes use of relatively small filament diameters, which increases the manufacturing cost in drawing.
Apart from the winding of the wrapping filament, three individual twisting steps are needed to manufacture the final cord. The outer layer is twisted in a direction opposite to the twisting direction of the core and the intermediate layer.
If use is made of a double-twister, this means that in the intermediate 3+9-cord the twisting steps must be much smaller than in the final 3+9+15-cord, since an amount of the twisting of the 3+9 gets lost in the final twisting of the 15 in the opposite direction around the 3+9. This again increases considerably the manufacturing costs.
This latter drawback can be avoided by manufacturing the 3+9+15-cord by means of a tubular twisting machine, but such a tubular twisting machine has, as is well known in the art, an output which is moderate in comparison with the output of a double-twister.

Yet another disadvantage is that a 3+9+15-cord has no full rubber penetration. This is, amongst other reasons, due to the presence of a 1x3-core with an internal void.

The prior art has already provided a 3+9-cord and a 3+8-cord as alternative constructions to replace a 3+9+15-cord. These constructions have a greater filament diameter in order to obtain a comparable breaking load and they can be manufactured in only two twisting steps. So these alternatives are cheaper than a 3+9+15-cord. They have, however, still the drawback of incomplete rubber penetration due to the 1x3-core.

SUMMARY OF THE INVENTION

It is an object of the present invention to avoid the drawbacks of the prior art.
It is also an object of the present invention to provide for an alternative for a 3+9+15-construction which is cheaper in manufacturing cost than a 3+9+15-construction and which has full rubber penetration.

According to a first aspect of the present invention, there is provided for a steel cord for the reinforcement of rubber articles. The steel cord comprises a core filament with a first diameter d_1, four or five intermediate layer filaments with a second diameter d_2 and ten outer layer filaments with a third diameter d_3. The intermediate layer filaments surround the core filament and the outer layer filaments surround the intermediate layer filaments. The first diameter is smaller than the second diameter and is greater than the diameter of the circle inscribed in the compact figuration of the cross-sections of the intermediate layer filaments in the case of no core filament.
This cord construction, which is a 1+4+10-cord or a 1+5+10-cord, can be manufactured in two twist steps and has full rubber penetration.

Four or five intermediate layer filaments are provided since the provision of only three intermediate layer filaments would lead to a less stable structure or to diameters of intermediate layer filaments which are too great with respect to fatigue resistance. The provision of six or more intermediate layer filaments would lead to diameters of intermediate layer filaments which are too small with respect to cost of drawing.
Ten outer layer filaments are provided since the provision of only nine or less outer layer filaments would lead to a less stable structure or to diameters of outer layer filaments which are too great with respect to fatigue resistance. The provision of eleven or more outer layer filaments would lead to diameters of outer layer filaments which are too small with respect to cost of drawing.

Preferably, the second diameter d_2 is substantially equal to the third diameter d_3. This avoids the use of three different filament diameters.

The direction of twisting of the intermediate layer filaments is preferably equal to the direction of twisting of the outer layer filaments. As explained hereabove with respect to a 3+9+15-construction, an equal direction of twisting also decreases the manufacturing cost if the technique of double-twisting is used.

Usually the twist pitch p_2 of the intermediate layer filaments is smaller than the twist pitch p_3 of the outer layer filaments. For example, following relation can be applied :

$$p_2 = (0.4 \text{ à } 0.8) \times p_3$$

In an advantageous embodiment, the steel cord according to the present invention has a core filament with a wave form. Preferably, the pitch of the wave form is different from the twist pitch of the intermediate layer filaments.

This embodiment has the advantage of preventing the core filament from migrating out of the remaining steel cord filaments when put under alternating bending loads.

According to a second aspect of the present invention, there is provided for a heavy truck tire comprising one or more belt layers. At least one of the belt layers is reinforced with a steel cord according to the first aspect of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in more detail with reference to the accompanying drawings wherein

- FIGURE 1 illustrates the meaning of 'inscribed circle' ;
- FIGURE 2 shows a transversal cross-section of a first embodiment of a cord according to the present invention ;
- FIGURE 3 shows a transversal cross-section of a second embodiment of a cord according to the present invention ;
- FIGURE 4 shows part of a cross-section of a heavy truck tire comprising three belt layers, at least one of which is reinforced with a cord according to the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

In order to illustrate the meaning of the terms 'inscribed circle', FIGURE 1 shows the cross-section four intermediate layer filaments 10 contacting one another after the core filament has taken out from the center. The four filaments 10 form a closed compact configuration. Assuming that the transversal cross-sections of these filaments are circles, another circle 12 contacting these circles can be inscribed in the center. Circle 12 is called 'the circle inscribed in the compact figuration of the cross-sections of the intermediate layer filaments in case of no core filament'. The diameter d_1 of the core filament is substantially greater than the diameter of the inscribed circle 12, e.g. at least 5 % greater.

FIGURE 2 shows the transversal cross-section of a 1+4+10-cord 14 according to the present invention : a core filament 16 with a diameter of 0.175 mm is surrounded by four intermediate layer filaments 10 of diameter 0.28 mm which are on their turn surrounded by ten outer layer filaments 20 with diameter 0.28 mm. This cord can be summarized as :

$$1x0.175 + 4x0.28 + 10x0.28 \quad 9/18 \quad S/S$$

which means that the twisting direction of the intermediate layer is equal to the twisting direction of the outer layer and that the twisting step p_2 of the intermediate layer is half the value of the twisting step p_3 of the outer layer.

FIGURE 3 shows the transversal cross-section of a 1+5+10+1-cord 14 according to the present invention. A core filament 16 of a diameter 0.20 mm is surrounded by five intermediate layer filaments of a diameter 0.25 mm which are in their turn surrounded by ten outer layer filaments 20 of a diameter 0.25 mm. A wrapping filament 24 of a diameter 0.15 mm may be wound around the outer layer either in the same twisting direction or in the other twisting direction of the outer layer. This cord can be summarized by the following formula :

$$1x0.20 + 5x0.25 + 10x0.25 + 0.15 \quad 9/18/5 \quad S/S/Z$$

FIGURE 4 partly shows the cross-section of a heavy truck tire 26 having belt layers 28, a carcass layer 30 and a bead reinforcement 32. At least one of the belt layers 28 is reinforced with steel cords 14.

TEST 1

The parameters and properties of three cords according to the present invention :

(1) 0.175 + 4x0.28 + 10x0.28 HT 9/18 S/S

(2) 0.20 + 5x0.25 + 10x0.25 HT 9/18 S/S

(3) 0.20 + 5x0.25 + 10x0.25 HT + 1 9/18/5 S/S/Z

have been compared with the parameters and properties of four cords of the prior art :

(4) 3 + 9 + 15 x 0.22 + 1 NT 6.5/12/18/3.5 S/S/Z/S

(5) 3x0.32 + 8x0.32 HT 9/18 S/S

(6) 3x0.32 + 9x0.30 HT 9/18 S/S

(7) 3x0.32 + 9x0.30 HT + 1 9/18/5 S/S/Z

The abbreviation 'HT' means high tensile and 'NT' means normal tensile.

Table 1 summarizes the test results :

Table 1 :

CONSTRUCTION ->	(1)	(2)	(3)	(4)	(5)	(6)	(7)
linear density (g/m)	7.1	6.2	6.3	8.4	7.1	6.9	7.1
cord diameter (mm)	1.29	1.16	1.44	1.60	1.31	1.27	1.50
breaking load (Newton)	2725	2311	2311	2724	2758	2644	2651
tensile strength (MegaPascal)	3009	2947	2946	2605	3045	3005	3014
yield strength Rp at 0.2% (MPa)	2595	2542	2535	2378	2614	2586	2550
permanent elongation at max. load (%)	0.92	1.01	1.06	0.53	1.18	1.15	1.24
total elongation at fracture (%)	2.57	2.62	2.68	1.97	2.78	2.84	2.88
P.L.E. (50 Newton) (%)	0.099	0.096	0.062	0.051	0.065	0.098	0.060
rubber penetration (press. drop meth.)	full	full	full	incompl.	incompl.	incompl.	incompl.

A 1 + 4 + 10-cord or a 1 + 5 + 10-cord has mechanical properties which are comparable to prior art cords 3 + 9 + 15, 3 + 8 or to 3 + 9, but has - in contradistinction with the prior art cords - full rubber penetration.

TEST 2

A 1+4+10-cord according to the invention and four prior art steel cords have been embedded in two belt plies of a tire with size 315/80 R 22.5. The width of the plies is 22 cm. The length of the plies is 325 cm, the rubber compound gage is equal to 0.60 mm, and the required strength per dm is 270 000 N/dm.
The 1+4+10-cord is as follows :

(1) 0.175 + 4x0.28 + 10x0.28 HT 9/18 S/S ;

and the prior art cords are as follows :

(2) 3+9+15 x 0.22 + 1 NT 6.5/12/18/3.5 S/S/Z/S ;
(3) 3x0.32 + 8x0.32 HT 9/18 S/S ;
(4) 3x0.32 + 9x0.30 HT 9/18 S/S ;
(5) 3x0.32 + 9x0.30 + 1 HT 9/18/5 S/S/Z.

Table 2 summarizes the results.

Table 2 :

CONSTRUCTION ->	(1)	(2)	(3)	(4)	(5)
cord diameter (mm)	1.29	1.60	1.31	1.27	1.50
breaking load (Newton)	2725	2725	2760	2645	2650
end count (epdm)	49	49	49	51	50
packing factor = epdm x diam. (%)	63	78	62	64	75
linear density (g/m)	7.1	8.4	7.1	6.9	7.1
ply gage (mm)	1.89	2.20	1.91	1.87	2.10
weight of cord in ply (g)	4981	5906	4873	5032	5076
weight of rubber compound in ply (g)	2379	2754	2427	2339	2710
total weight of plies (g)	7360	8660	7300	7371	7786
ply weight index	85	100	84	85	90

A 1+4+10-cord leads to a comparable ply weight as the 3+8- and 3+9-alternatives and to a ply weight which is considerably smaller than the one of a 3+9+15.

The present invention is not limited to a particular steel composition, a particular tensile strength or a particular coating promoting the adhesion to rubber or increasing the corrosion resistance.

In the same spirit is the present invention not limited to a particular plastical deformation of the core filament or of the intermediate layer or outer layer filaments.

By way of non-limitative examples only, the core filament can present following forms :

- a straight form, i.e. not subject to a particular deformation ;
- an undulated form in one single plane, e.g. as a consequence of plastical deformation between the teeth of two gears ;
- a three-dimensional undulated form, e.g. in the form of a helicoid with a direction which is opposite to the direction of twisting of the intermediate layer.

Claims

1. A steel cord for the reinforcement of rubber articles, said steel cord comprising a core filament with a first diameter d_1, four or five intermediate layer filaments with a second diameter d_2 and ten outer layer filaments with a third diameter d_3, the intermediate layer filaments surrounding the core filament and the outer layer filaments surrounding the intermediate layer filaments, the first diameter being substantially smaller than the second diameter and being substantially greater than the diameter of the circle inscribed in the compact figuration of the cross-sections of the intermediate layer filaments in case of no core filament.

2. A steel cord according to claim 1 wherein the second diameter d_2 is substantially equal to the third diameter d_3.

3. A steel cord according to one of the preceding claims wherein direction of twisting of the intermediate layer filaments is equal to the direction of twisting of the outer layer filaments.

4. A steel cord according to one of the preceding claims wherein the twist pitch of the intermediate layer filaments is smaller than the twist pitch of the outer layer filaments.

5. A steel cord according to one of the preceding claims wherein the core filament has a wave form.

6. A steel cord according to one of the preceding claims wherein the pitch of the wave form is different from the twist pitch of the intermediate layer filaments.

7. A heavy truck tire comprising one or more belt layers, at least one of said belt layers being reinforced with a steel cord according to one of the preceding claims.

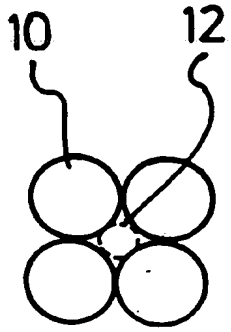

FIG.1

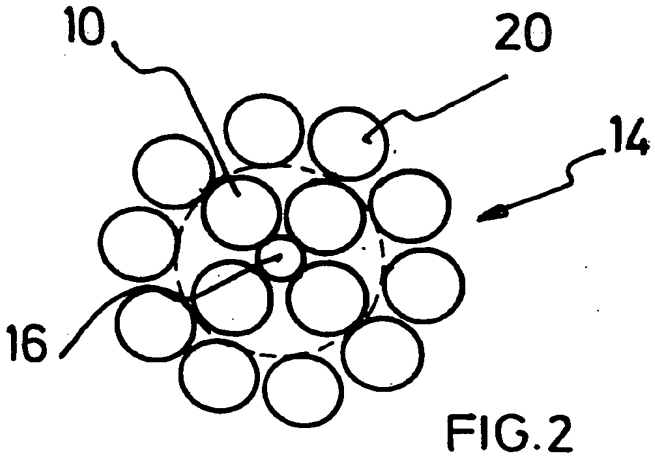

FIG.2

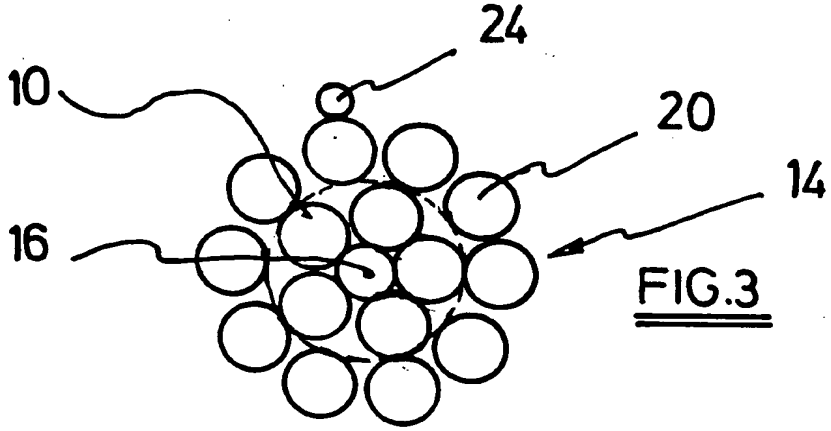

FIG.3

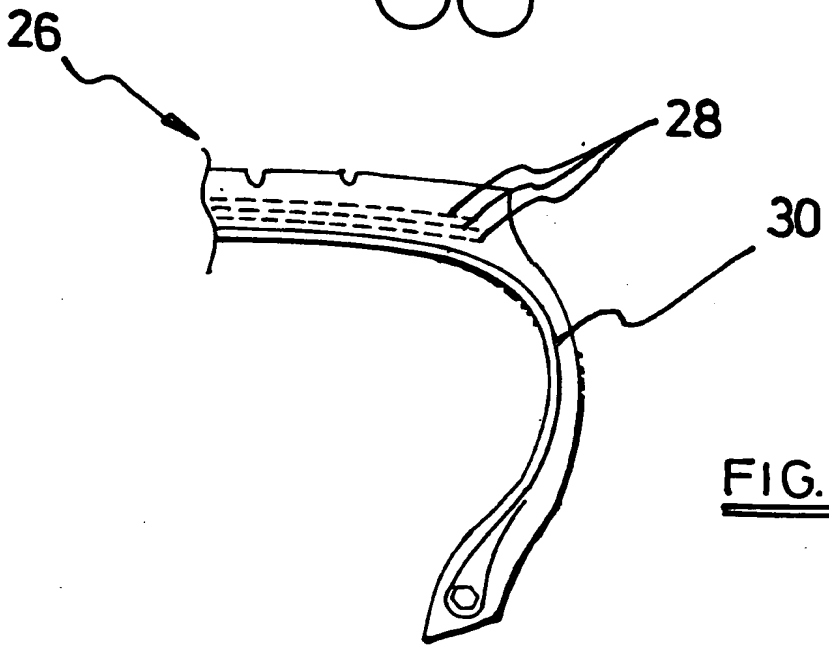

FIG.4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 0760

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	GB-A-2 080 845 (DUNLOP LTD.) * page 1, line 49 - page 2, line 30 * * page 2, line 51 - line 57 * * page 3, line 35 - line 43 *	1,3,4,7	D07B1/06
A	US-A-4 781 016 (M.SATO; T.SUGAWARA) * column 2, line 31 - column 3, line 35 *	1-4,7	
A	RESEARCH DISCLOSURE, no.316, August 1990, EMSWORTH GB page 681 316107 'Steel cord construction' * the whole article *	1,2,5,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) D07B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 July 1994	Goodall, C

CATEGORY OF CITED DOCUMENTS

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